BASE LINE STUDY OF ENVIRONMENTAL CONDITIONS

Final Report
Project No. 21-1583
Contract NAS 9-3419

by

Herbert C. McKee
L. L. Hiser

to

National Aeronautics and Space Administration
Manned Spacecraft Center
2101 Webster-Seabrook Road
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January 4, 1967

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I. INTRODUCTION

This report presents results obtained during the subject contract, which covers a base line study of environmental conditions at the Manned Spacecraft Center site and surrounding areas, near Houston, Texas.

The study was conducted to meet the following objectives:

A. Provide data to be sure that MSC operations fit into the environment with no undesirable effects on the surrounding communities.

B. Identify existing environmental conditions which might impose limitations on waste disposal, corrosion of equipment, water supply, or other factors of MSC operations.

C. Provide a basis for establishing a firm defensive position in the event of accusations of pollution effects on the environment at a later date.

D. Provide data to aid in the development of a program to maintain proper environmental controls as MSC expands and as changes are made in various operations.

A previous study* outlined the general environmental conditions existing in the MSC area and developed the general outline for this study. As the work progressed, additional emphasis was placed on monitoring of environmental conditions at MSC to provide adequate protection for MSC employees as well as for residents of the surrounding communities.

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* Environmental Control and Effects Study, NAS 9-1284, November 11, 1963. Performed by Southwest Research Institute, Houston, Texas

II. WATER POLLUTION PROBLEMS IN THE CLEAR LAKE AREA

In this section of the report, a general discussion is given of various problems of water pollution in the Clear Lake area with an indication of how MSC operations are related to these problems. Results are also presented for experimental work conducted under this contract and by other agencies to illustrate the nature and magnitude of the various problems which exist.

A. Surface Water

With the rapid development of the areas around Clear Lake, water pollution problems are becoming matters of paramount importance to the local residents. Due to the rapid growth of both residential and business developments, existing sewage treatment plants have been overloaded for some time with the result that water quality in Clear Creek and Clear Lake has deteriorated.

This situation has been a cause of concern for the Texas Water Pollution Control Board due to the importance of Clear Lake as a recreational area, and also because Clear Lake is a part of the Galveston Bay system which is an important natural resource from the standpoint of fish, oysters, shrimp, recreation, and water transportation.

In order to reverse this trend and maintain the recreational and other values of Clear Lake and the surrounding bodies of water, a Clear Creek basin authority has been formed to coordinate the efforts of various agencies and municipalities involved. This agency plans ultimately to initiate a coordinated program for control of all sewage treatment and other waste disposal problems in the area. In the meantime, however, the State Water Pollution Control Board has also initiated an active program to secure better treatment from the existing plants in the area, which number approximately 26 at the present time. Standards for all sewage treatment plants in the area have been set by the Board to include the following:

BOD	20 mg/l maximum
Suspended Solids	20 mg/l maximum
Chlorine Residual	1.0 mg/l minimum

Methods of measurement and schedules for sampling have also been established. Data on the MSC sewage treatment plant have been supplied to the Board from information furnished by the contractor presently operating this facility at MSC.

An indication of the severity of the problem is available from State Health Department data, obtained through the cooperation of that agency. This department has been conducting a continuing water quality survey in Galveston Bay since 1962 as an aid to the development of water quality standards and adequate control measures. Figure 1 shows the location of sampling points used by the state in the Clear Lake-Clear Creek vicinity. Table 1 summarizes the bacteriological results which have been obtained from these sample points and shows the trend of water quality in Clear Lake and vicinity. A comparison of the figures for the various years shows that bacteriological counts are generally increasing in Clear Lake and Clear Creek. It appears that the efforts which have been exerted are not sufficient to counteract the pollution resulting from increased development of the area. In view of the necessary lead time for construction or improvement of sewage treatment facilities by subdivisions, towns, and cities in the area, some period of time will likely pass before a great improvement can be effected. Meanwhile, the Water Pollution Control Board is continuing its efforts to obtain the best results from the available facilities.

During the period covered by this study, several fish kills were observed in Clear Lake and Clear Creek following heavy rains. On at least one occasion, a fish kill in Clear Creek occurred simultaneously with a fish kill in the Houston Ship Channel, and other similar incidents may have escaped detection. When these conditions were detected, an investigation was made to determine the nature and extent of this phenomenon to see if MSC operations could be responsible in any way.

In all cases which were observed, fish kills occurring in Clear Creek originated upstream from the Manned Spacecraft Center, thus indicating that effluent from MSC was not responsible. There is no evidence that the kill was heavier adjacent to points where waste water from MSC was released. Sufficient data were not available to determine the cause of these kills but several possible causes can be suggested. One is decomposition of algae following some of the heavy algae blooms which are occasionally observed in Clear Lake. Another possible cause is a rapid change in the salinity of the water due to heavy runoff after excessive rains. In the Houston Ship Channel, release of industrial waste water is probably implicated, but this is not likely to be an important factor in Clear Creek. It has also been suggested that these kills may be related to agricultural pesticides or to mosquito spraying programs. On at least one occasion, a kill in Clear Lake was observed immediately following heavy rains a short time after an extensive mosquito spraying campaign was conducted in Houston and Harris County because of an epidemic of encephalitis (1964).

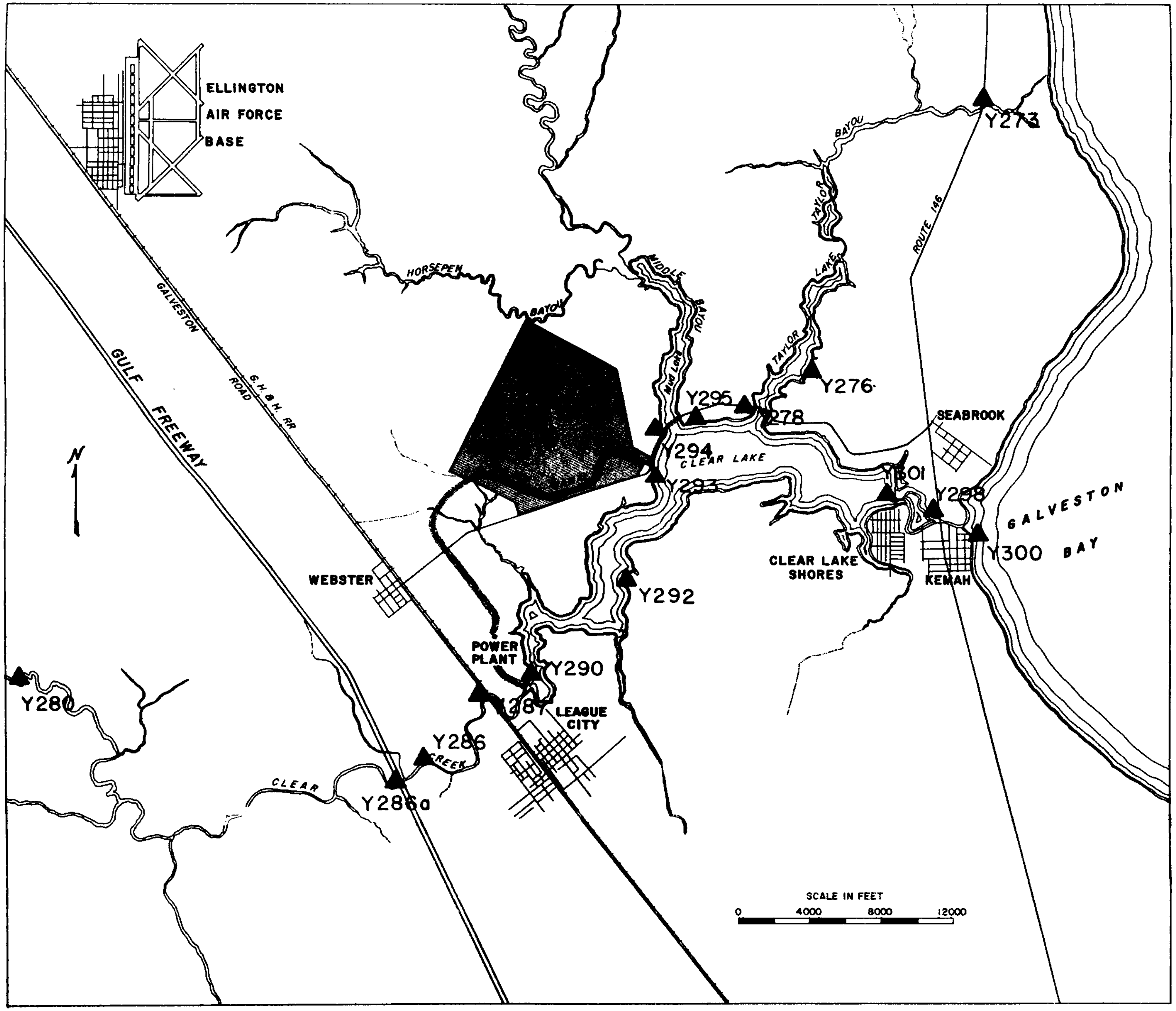

FIGURE 1 - STATE HEALTH DEPARTMENT SURFACE WATER SAMPLE POINTS

Geometric Mean

Most Probable Number per 100 ml (MPN)

Sample Station	1963	1964	1965	1966[2]
Y279 A	16,200	11,000	5,400	16,000
Y280	1,700	4,400	5,600	2,500
Y286 A	970	2,600	1,200	1,900
Y286	1,300	2,700	1,000	3,300
Y287	1,820	2,800	1,500	2,200
Y290	430	1,400	900	1,400
Y293	345	1,900	6,300	6,000
Y294	355	650	1,800	3,400
Y295	235	600	3,000	2,400
Y301	120	230	1,500	8,300
Y298	245	620	—	—
Y300	420	120	3,500	1,800
Y273	11,200	2,100	—	—
Y276	630	1,000	5,900	—
Y278	270	570	3,200	4,300

(1) From Texas State Department of Health data from the Galveston Bay Survey Project.

(2) Through August 24, 1966

TABLE 1

Surface Water Coliform Bacteria MPN[1]
Clear Lake Area - 1963, 1964, 1965, and 1966

Wastes from the Photographic Services Laboratory are still being discharged to Clear Lake through Ditch 25 and Cow Bayou. The impending problem posed by this waste discharge has been documented in several previous reports.

Table 2 illustrates the problem of oxygen depletion found in Ditch 25 as a result of this waste discharge. However, a more visible problem is the propagation of algae in Cow Bayou which results from the phosphorous and other nutrients supplied by this waste discharge.

B. <u>Ground Water</u>

The previous report outlined the general problems of ground water supply along the Gulf Coast. In particular, it was noted that salt water encroachment and ground subsidence have occurred in some areas due to heavy withdrawal of ground water. While such problems are not the responsibility of MSC, it should be kept in mind that eventually other sources of water will be needed. Work is now in progress by the City of Houston and other agencies to obtain additional supplies of surface water so that eventually withdrawal of ground water can be reduced.

From the standpoint of MSC, the important aspects of the ground water situation are the necessity to prevent pollution of ground water supplies that could be used elsewhere in the immediate vicinity. While there is no reason to suspect that any of the present MSC operations would result in contamination of ground water, a monitoring program was instituted as an additional safeguard. Seven producing water wells (including both MSC wells) were selected in the Clear Lake vicinity for use in this monitoring program. Periodic sampling and analysis of water from these test wells was conducted in order to identify and document any changes which might occur in water quality. Table 3 lists these selected wells with the pertinent data and well water analyses developed on each. No significant trends or indications of ground water contamination were noted over the 16-month sampling period.

On the MSC site, four shallow test wells were also provided immediately adjacent to the Thermochemical Test Area in order to detect any contamination which might occur as a result of seepage of waste materials from the Thermochemical Test Area or improper treatment and disposal of waste materials. Information on these wells is included under Section IV.

Sample Location (Date / Time)	12/6/65 1330 - 1630 D.O.	% Sat.	12/28/65 0900 - 1030 D.O.	% Sat.	2/21/66 1630 - 1745 D.O.	% Sat.	2/22/66 0830 - 0935 D.O.	% Sat.	2/24/66 D.O.	% Sat.
1. Ditch 25 Above sewer inlet	11.0 mg/l	122%	8.0 mg/l	70%	9.5 mg/l	115%	11.5 mg/l	107%	10.5 mg/l	98%
2. Ditch 25 At sewer inlet	5.5 mg/l	63%	5.0 mg/l	51%	5.0 mg/l	58%	2.0 mg/l	21%	2.5 mg/l	24%
3. Ditch 25 100 ft below sewer inlet	7.0 mg/l	80%	5.5 mg/l	52%	6.6 mg/l	77%	5.0 mg/l	53%	5.5 mg/l	53%
4. Ditch 25 North side of HPL canal	10.0 mg/l	111%	5.5 mg/l	50%	—	—	—	—	—	—
5. Ditch 25 25 ft S of HPL canal	10.0 mg/l	109%	4.7 mg/l	39%	8.8 mg/l	104%	6.6 mg/l	62%	5.0 mg/l	45%
6. Ditch 25 Mouth at Cow Bayou	12.5 mg/l	127%	5.0 mg/l	41%	9.4 mg/l	113%	—	—	8.5 mg/l	80%
7. Cow Bayou Above mouth of Ditch 25	10.2 mg/l	147%	7.5	65%	—	—	—	—	—	—
8. Cow Bayou 1/2 mi S of FM528	7.0 mg/l	80%	—	—	9.0 mg/l	107%	10.0 mg/l	101%	—	—

TABLE 2 DISSOLVED OXYGEN PROFILES IN DITCH 25 DUE TO PHOTOSERVICES LABORATORY WASTE DISCHARGE

Well or Owner	Clear Lake City #1	Clear Lake City Golf #1	NASA Well #1	NASA Well #2	WC&D #60 El Carey	WC&D #50 El Lago #1	Seabrook Well #2
USGS Well No.	406	410	404	405	501	602	603
Depth - feet	657'	628'	627'	629'	600'		
Screen	395-657'	—	530-622'	536-624'	530-570'		
Electric Log	Yes	Yes	Yes	Yes	Yes		
Casing	18"-10"	12"-6"	20"-14"	20"-14"-12"	6"-4"	—	—
Approx. Ground Elevation	—	—	22'	21'	17'	—	—
pH - Units	8.1	8.0	8.2	8.2	7.9	7.9	7.9
Total Residue - mg/l	431	392	438	459	507	636	528
Filtrable Residue mg/l (Dissolved Solids)	410	382	433	429	498	635	512
Non-Filtrable Residue mg/l (Suspended Solids)	4	13	8	13	9	2	18
Ca - mg/l as ion	10	10	5	5	6	9	8
Mg - mg/l as ion	6	6	5	5	6	6	5
Na & K (by diff.) as ion	149	131	154	157	177	224	202
SO_4 - mg/l as ion	4	1	<1	2	4	1	<1
Cl - mg/l as ion	72	52	69	72	99	138	125
F - mg/l as ion	1.1	.9	1.5	1.2	1.5	1.6	1.5
NO_3 - mg/l as ion	0.8	1.9	1.9	0.6	0.7	1.7	2.0
Alkalinity - mg/l as $CaCO_3$							
P - mg/l as $CaCO_3$	0	0	0	0	0	0	0
M - mg/l as $CaCO_3$	255	259	268	268	281	337	291
Total Hardness - mg/l as $CaCO_3$	48	48	32	32	34	47	40
Conductivity - mho	641	584	632	648	757	1009	828

Note: Data shown are arithmetic averages of 5 to 7 analyses made on water samples taken at approximately three-month intervals from October 1964 through June 1966.

TABLE 3 - GROUND WATER - DEEP WELL DATA AND AVERAGE WATER ANALYSES

III. AIR POLLUTION PROBLEMS IN THE CLEAR LAKE AREA

A. General Problems of the Houston Area

The most complete information on air pollution conditions in the Houston area is available from two surveys which have been conducted under the sponsorship of the Houston Chamber of Commerce.* The first of these was conducted in 1956-58 and the results were outlined in a previous NASA report. This survey established a "benchmark" for comparison with later conditions and also described the general air pollution situations and factors which influence these patterns in Harris County.

The second survey was conducted in 1964-66 in order to identify and document changes which occurred in the intervening eight-year period. As part of the background for subsequent discussion of air pollution in and around the MSC site, it is appropriate to review the important findings of that survey to illustrate the changes which are taking place throughout the community.

Many aspects of the pattern of air pollution in the Houston area are similar to conditions at the time of the 1956-58 survey. Some changes have occurred in various areas of the community because of population growth, changes in industrial operations, and other factors which affect air pollution. The various problems which exist can best be described as a series of localized problems downwind from particular sources of pollution. A true community-wide pollution problem which affects the entire community simultaneously, similar to that found in some other cities, does not exist in the Houston area at the present time.

This distinction, of course, does not minimize the importance of some of the localized problems that exist. However, this distinction is important in understanding the nature of these problems and planning future corrective or preventive action. These various local problems are influenced to a major degree by weather conditions. The most undesirable situation occurs with the wind in the east to northeast, which allows pollutants from several different sources in the Ship Channel area

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* Southwest Research Institute. Air Pollution Survey of the Houston Area. Houston Chamber of Commerce, July, 1958.

Southwest Research Institute. Air Pollution Survey of the Houston Area, 1964-1966. Houston Chamber of Commerce, October, 1966.

to accumulate in a given air mass and thus produce higher concentrations downwind than would occur if this mixing did not take place. On some occasions a given air mass will move lengthwise over a major portion of the heavy industrial district along the Houston Ship Channel and accumulate pollutants from such a variety of sources that the area which is affected downwind can extend for several miles into downtown Houston.

The severity of air pollution in Houston depends on location. Residents who live near the Ship Channel industrial district are aware of air pollution as a series of nuisances from odors, dust, or other air pollution manifestations and these effects change depending on which way the wind is blowing. Residents on the west side of town are aware of air pollution primarily as haze which is visible in the atmosphere on a limited number of days when high humidity, low wind velocity and air pollution combine to produce a very hazy appearance.

In comparing the results of the two surveys, it is interesting to note the growth of the community and of several factors which influence air pollution problems. During the eight-year period between these two surveys, population in Harris County increased 32%, motor vehicle registration increased 52%, and the value added by manufacturing increased 80%. With these various increases, it is inevitable that changes would occur in the air pollution patterns of the community.

A comparison of the results of the two surveys shows the following:

1. Sulfur compounds from industrial sources have remained approximately constant despite the increases in industrial activity.

2. Oxides of nitrogen from combustion sources have increased. This increase is due in part to an increase in vehicle traffic and in part to industrial use of fuel as a source of energy.

3. The average dust concentration in the atmosphere has increased to some degree.

4. The presence of "oxidant" (comprised of ozone and other oxidizing materials) has shown a significant change. During the 1956-58 survey, data on oxidant concentrations showed no evidence of the photochemical reactions in the atmosphere which are characteristic of the Los Angeles smog situation and have since been observed in many other cities. In the 1964-66 survey,

however, occasional evidence was found of these reactions which demonstrates that vehicle traffic and other sources of pollution have increased to the point where the Los Angeles type reactions do occur in the atmosphere. This situation has not yet progressed to the point where eye irritation and other undesirable manifestations of this particular type of air pollution would be expected, but with the continued growth of the community and continued expansion of industrial activity, this point would be reached at some future time if steps were not taken to prevent such a situation.

Fortunately, there is reason to hope that this situation will not increase to an undesirable level. Recent federal regulations have been adopted which require the installation of control devices on automobiles, and all new cars starting with the 1968 model year will be so equipped. Within a few years, a substantial portion of the vehicle population in the Houston area will be equipped with such devices, and thus there is reason to believe that the development of this new type of air pollution problem in Houston will be arrested before it has progressed to the point where eye irritation or other difficulties occur.

The nuisance conditions which are most obvious to the residents of the community include the following:

1. Odor nuisances downwind of particular sources of odorous emissions.

2. Dust concentrations which in some areas are high enough to create a nuisance by settling out on furniture, automobiles, etc.

3. Visibility reduction which is evident as a heavy haze in the atmosphere.

B. Conditions in the Clear Lake Area.

In contrast to the pollution problems encountered in the City of Houston and in the Ship Channel industrial area, air pollution is a very minor factor in the Clear Lake area because of the isolated location relative to significant sources of pollution. However, the MSC site is located sufficiently close to the Ship Channel area and to the Texas City industrial area that it is important to establish the conditions which now exist and to determine whether or not these industrial areas are responsible for any emissions which can be observed in the environment around the MSC site. Therefore, sampling and analysis was conducted in and around the MSC site to measure any contaminants which could be detected and to evaluate the results in terms of the present and potential air pollution problems in the Clear Lake area.

Much of this work was accomplished by using a mobile laboratory which made it possible to collect and analyze samples immediately and thus eliminate the necessity for returning samples to a permanent laboratory for analysis. This elimination of a time delay in securing analytical results increased the flexibility of sampling and also made it possible to obtain more accurate results. Figure 2 shows an exterior view of this laboratory. Figure 3 is an interior view which shows some of the air sampling equipment used, while Figure 4 shows some of the analytical facilities available.

Since atmospheric concentrations of various pollutants change depending on changes in emission levels and weather conditions, it is necessary to obtain data under a wide variety of conditions in order to produce an accurate evaluation of air pollution conditions. Therefore, sampling was conducted during all seasons of the year and at various hours of the day over an extended period. Much of this was done while the mobile laboratory was at MSC for other work as a part of this project.

The first potential source of contamination considered was the industrial complex at Texas City, approximately 18 miles southeast of the MSC site. In all of the sampling conducted, no measurable amount of any atmospheric contaminant was detected which could be attributed to this source.

The second potential source of contamination is the tremendous industrial complex located along the Houston Ship Channel. Various portions of this complex are from 10 to 15 miles north of the MSC site. As will be described subsequently, minor evidence of contamination from this area was occasionally detected at MSC but was relatively minor. At the present time, it would appear that such contamination would not have any adverse effects at MSC such as acceleration of corrosion, vegetation damage or other undesirable manifestations.

Data for various contaminants are discussed separately in the paragraphs which follow:

FIGURE 2 - EXTERIOR OF MOBILE LABORATORY

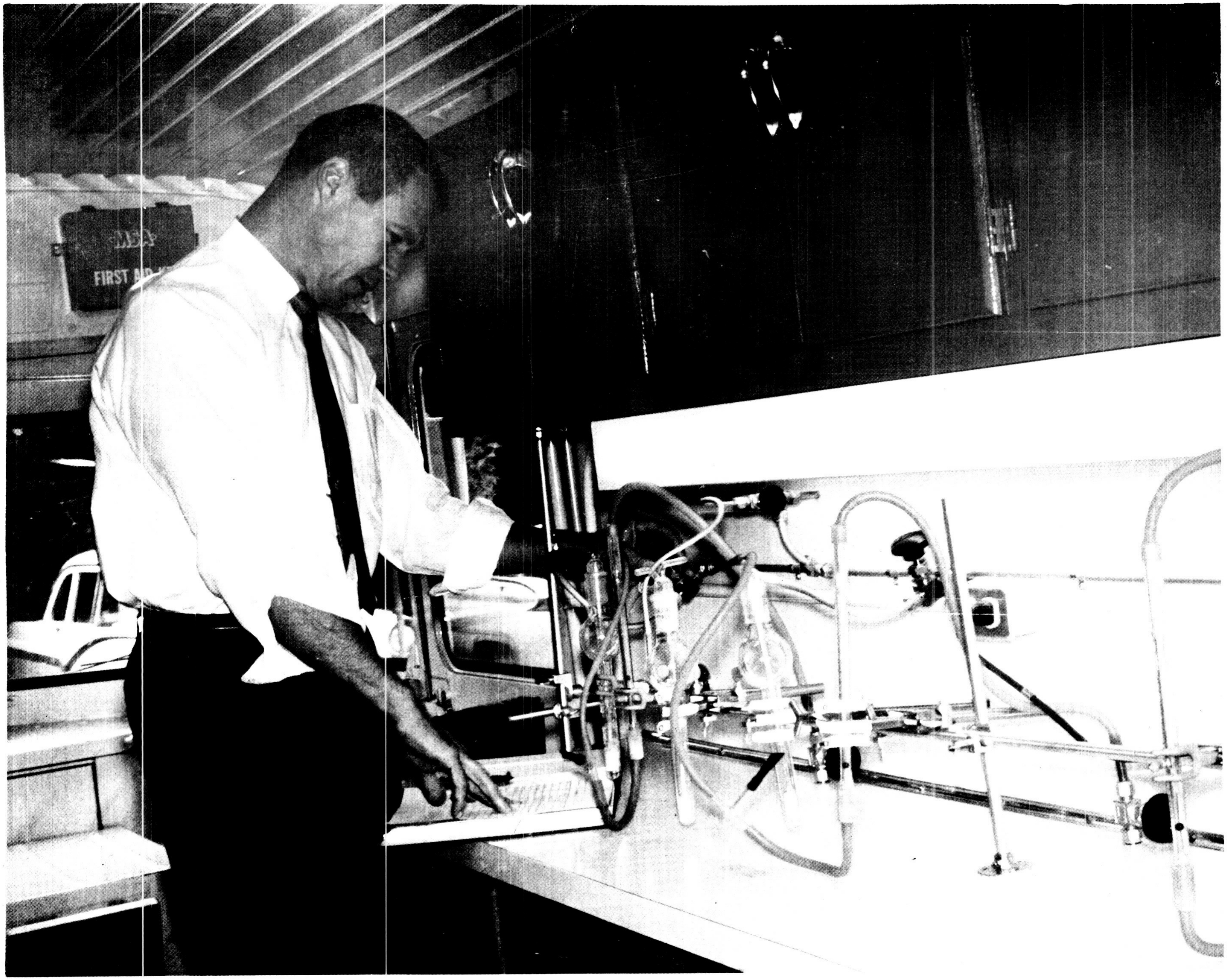

FIGURE 3 - INTERIOR OF MOBILE LABORATORY

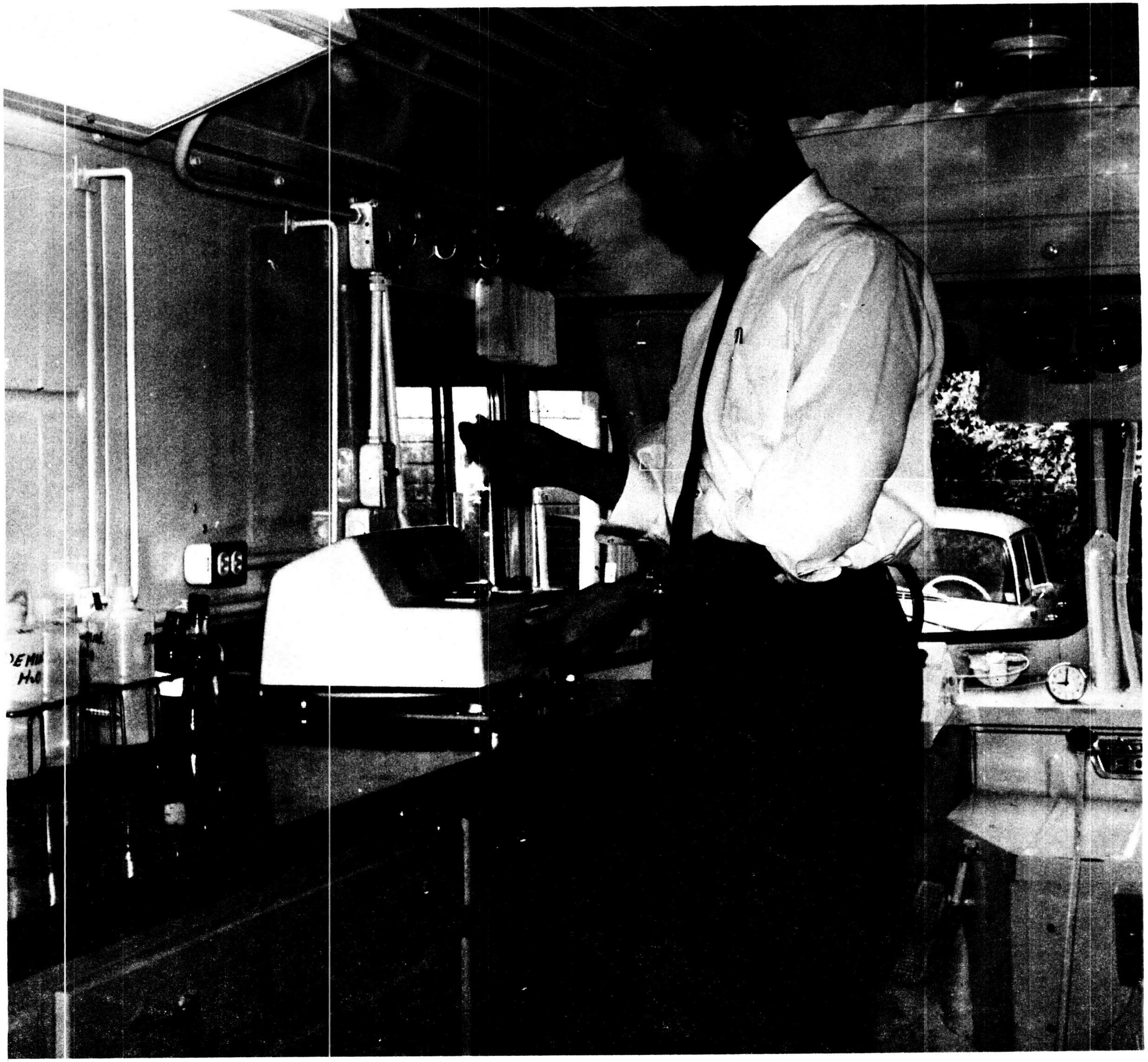

FIGURE 4 - MOBILE LABORATORY ANALYTICAL FACILITIES

Sulfur Dioxide. Sulfur dioxide occurs in the Ship Channel area and elsewhere in the Houston urban environment as a result of emissions from a variety of industries including petroleum refineries, chemical plants, fertilizer plants, and others. However, none of these are close enough to the MSC site to be an important source of atmospheric sulfur dioxide. Almost three-fourths of the samples collected in and around the MSC site showed no detectable amount of sulfur dioxide while most of the remainder showed only a slight trace which was too small to determine quantitatively. The highest single value obtained was 0.01 ppm on a day when the wind was in the north and atmospheric dispersion was very poor thus allowing some contaminants to be transported to the MSC site from the Ship Channel area. By comparison, values measured in different portions of the Ship Channel industrial district frequently range from 0.1 up to a maximum of 1.0 ppm in the recent air pollution survey in this area. Therefore, it was concluded that pollution from sulfur dioxide is of no importance in the Clear Lake area.

Nitrogen Dioxide. Another contaminant of some importance as an atmospheric pollutant is the oxides of nitrogen which are emitted by high temperature combustion sources. Determinations made in the Clear Lake area were quite low, usually being near the limit of detection of the analytical methods used. Of the various oxides of nitrogen, measurement of nitrogen dioxide (NO_2) was selected as a means of evaluating possible contamination from this group of materials.

While very small amounts of nitrogen dioxide might be transported to the Clear Lake area from the Ship Channel area during periods when the wind is in the north, this could not be detected with the sampling techniques used. The small amounts which were measured appeared to be practically independent of wind direction and probably resulted primarily from motor vehicle traffic in the area. Based on these very low readings, contamination from oxides of nitrogen in the Clear Lake area appears to be negligible by comparison with conditions in more densely populated urban areas where vehicle density is greater and where large scale stationary combustion sources also exist.

Oxidant. Oxidant measurements were made in the Clear Lake area to see if there is any evidence of the atmospheric photochemical reactions which characterize the Los Angeles smog problem and have been observed elsewhere. In the Houston area, such reactions have been documented both in the Ship Channel industrial district and in downtown Houston.

Very low oxidant values up to a maximum of perhaps 0.05 or 0.06 ppm are due to ozone in the air which results from natural causes, and do not represent man-made contamination. Values in excess of this figure however, are usually due to photochemical reactions in the atmsophere. In the Houston area, the highest single value obtained in a recent survey was 0.13 ppm, with other values ranging from the natural maximum of 0.06 up to that figure. These values were indicative of the photochemical reactions in areas of heavy industrial concentration and/or high density of motor vehicles.

In the Clear Lake area, practically all of the results obtained were in the range to be expected from natural ozone, from zero to 0.05 or 0.06 ppm. These followed the usual pattern, showing zero readings during nighttime hours or during cloudy weather, ranging up to the higher values in the middle of the day when maximum sunlight intensity existed. On a very few occasions when the wind was in the north and the atmosphere was extremely stable, higher values were observed. The highest single value was 0.09 ppm measured on two different days, while values of 0.06 to 0.08 ppm were also measured on a limited number of occasions. These values are taken as indications of photochemical reactions involving oxides of nitrogen and hydrocarbons emanating in the Ship Channel industrial district 10 to 15 miles to the north. The occurrence of such values in the Clear Lake area was independent of location within the area which indicates that local sources around MSC were not implicated in any way. Thus, while the photochemical reactions are occurring in this area, the degree of contamination produced is negligible and is not a matter of any immediate importance so far as MSC operations are concerned. The threshold concentration required to produce eye irritation or vegetation damage from this particular type of air pollution is thought to be around 0.15 ppm, considerably above any value measured in the Clear Lake area during the course of this investigation.

In summary, the results obtained indicate that air quality in the MSC and Clear Lake area is excellent, with no evidence of a significant degree of contamination. Traces of sulfur dioxide and oxidant can be measured occasionally which emanate in the Ship Channel industrial area. Traces of nitrogen dioxide and possibly other contaminants can be measured as a result of vehicle traffic, construction, or other activities in the immediate area. Neither of these are of sufficient severity to cause any effects such as vegetation damage, corrosion, or other significant undesirable manifestations of atmospheric pollution.

C. Vegetation Survey

Damage to vegetation is an important consideration in any community air pollution problem. In the previous study, an inspection of vegetation was made in the Clear Lake area to determine what patterns existed which might be related to air pollution problems in the area. A description was also given of visible damage to vegetation in the Houston Ship Channel area resulting from air pollution.

During this investigation, additional inspections were made to identify and document any changes in the vegetation patterns which might be related to air pollution or which might be alleged to result from air pollution in the area. Primary emphasis was placed on native trees and shrubs in the Clear Lake area although additional observations were also made at other locations in Harris and Galveston counties.

No evidence of visible damage due to air pollution was found anywhere near the MSC site. This was not unexpected since this is predominately a rural area except for the development of the MSC site itself and the surrounding residential and commercial areas which have been growing rapidly. By comparison with most urban areas, however, the existing air pollution in the area is still far below the level at which any damage to vegetation would be expected.

As is usually the case, symptoms were found on various types of vegetation which might be confused with air pollution damage by those not familiar with such symptoms. Examples include insect damage, diseases (chiefly fungus) and injury due to unusual weather conditions or other factors. All such symptoms which were found in the Clear Lake area could be ascribed to causes other than air pollution.

The combined effects of rainfall variation, grazing and other agricultural practices have produced some changes in the vegetation pattern in the undeveloped areas around the Manned Spacecraft Center which are still devoted to agricultural land use. Over-grazing and decreased rainfall frequently lead to excessive growth of rough types of plants such as ragweed, marsh elder and baccharis in certain areas. This occurred during the 1965 growing season. The marsh elder (Iva) has become more prevalent in the entire Texas Gulf Coast area in the past four or five years. This plant is related to the ragweed and the seeds are spread by high winds.

Rainfall was above average during the spring of 1966, which resulted in a rapid growth of all types of vegetation. Ragweed, marsh elder and similar plants were still present but were much less prevalent than during the fall of 1965 due to the rapid growth of other types of vegetation. Trees also made a rapid growth because of the heavy rainfall. Most trees had a very dense growth of leaves and for the most part were very healthy in appearance. As frequently happens when rapid growth occurs in the spring, some of the leaves dried out and became dormant during the hot, dry period later in the summer. This occurred as a natural result of the excessive growth rate in the spring and was not related to air pollution or other man-made influences.

Elsewhere in the Houston community, the pattern of vegetation damage as a result of air pollution is similar to that which has existed for several years and which was described in the previous report. Most of the visible damage is confined to the industrial area along the Houston Ship Channel where several species of trees show visible damage. Most of this is due to sulfur dioxide in the atmosphere, although in some cases, the observed effects may be accentuated by nutritional deficiency, lack of care or other factors not related to air pollution. Most of the visible damage is limited to an area within three to four miles of the Houston Ship Channel, and therefore does not extend to the MSC and Clear Lake areas. Visible damage has been noted on ash, elm, oak and cottonwood trees. In a few locations, continued exposure over a period of several years has caused the death of some oak and pine trees.

D. Radiation Measurements

Water and bottom deposit samples were obtained around the MSC site to provide data on background radiation. Since both beta and gamma emitting sources are used at MSC, a single gross count was made to determine total beta and gamma combined. In view of the very low background readings obtained, it was felt that a more refined measurement or the individual measurement of beta and gamma was not warranted. If high readings are obtained at a subsequent time, specific measurements of beta or gamma individually can be made and specific isotopes can be identified. This work was discontinued under this contract when a separate contract was negotiated for radiation services. However, the results obtained prior to that time are reported here for future record. On-site and off-site radiation sample points are located on Figures 5 and 6 respectively.

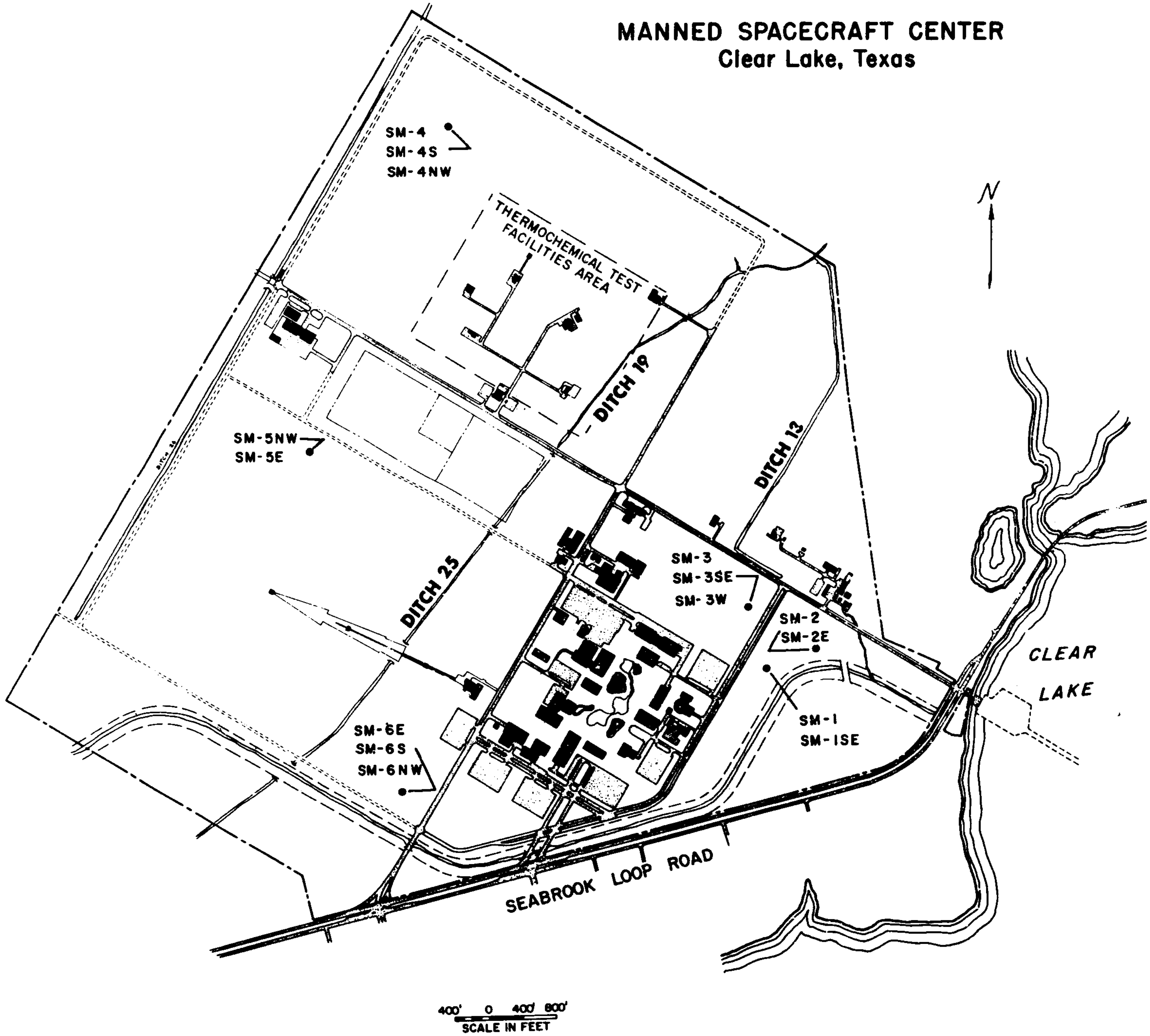

FIGURE 5 - ON-SITE RADIOLOGICAL SAMPLING POINTS

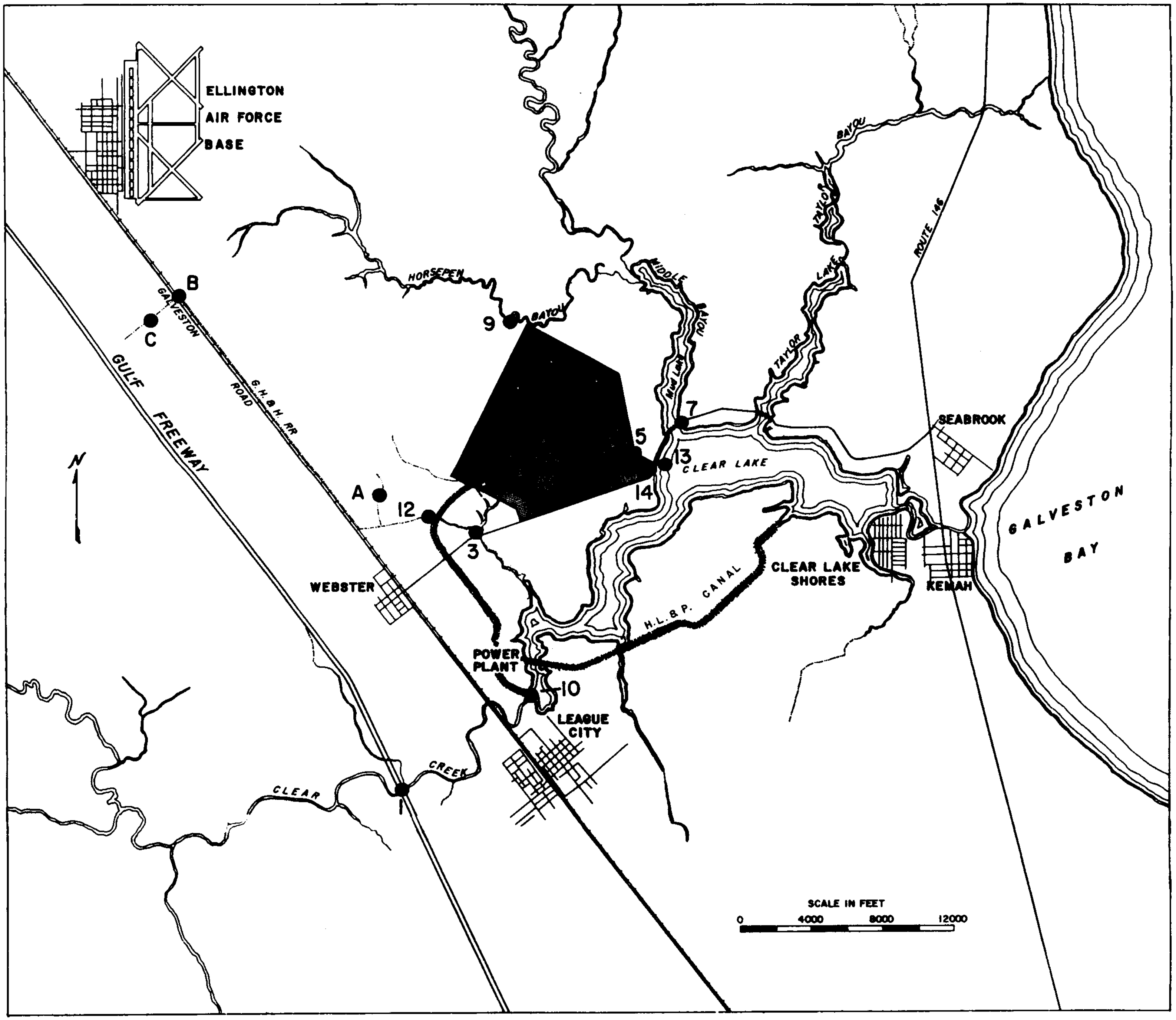

FIGURE 6 - OFF-SITE RADIOLOGICAL SAMPLING POINTS

Tables 4 and 5 show the results of the various samples which were taken at these sample points. All of the on-site results were quite low and can be considered in the range of normal background readings. Variations which occurred from one location to another are thought to be due to natural variations in background radioactivity and do not indicate any increase as a result of MSC operations. The relatively high counts noted in the off-site samples taken in Cow Bayou were traced upstream as far as points A and B in the drainage ditch along Highway 3. This ditch drains an oil field area. It was reasoned that MSC was not responsible for these count levels and this tracing was discontinued.

TABLE 4

GROSS BETA-GAMMA COUNT OF ON-SITE SAMPLES

SAMPLE POINT	LOCATION	SAMPLE DATE *	GROSS BETA-GAMMA WATER pc Tl-204 Equiv/liter	GROSS BETA-GAMMA BENTHAL pc Tl-204 Equiv/gm wet wt.
N-1	NASA sewage treatment plant - dried sludge	I	-	21 ± 3
		II	-	10 ± 1
		V	-	61 ± 5
N-2	NASA sewage treatment plant - stabilizer liquor	I	32 ± 5	-
		II	197 ± 24	-
		V	257 ± 33	-
N-2A	Sewage treatment plant wet well	V	87 ± 18	-
N-3	Sewage treatment plant effluent ditch at Ave. "B"	I	-	44 ± 9
N-4	Head of ditch 25 South of Ave. "B"	I	75 ± 10	23 ± 3
		II	54 ± 6	29 ± 3
		IV	95 ± 32	66 ± 3
N-5	Head of ditch 19 north of Ave. "B"	I	240 ± 31	71 ± 6
		II	20 ± 3	25 ± 3
		IV	-	102 ± 4
N-6	Confluence of ditches 13 and 19 at fence	I	17 ± 2	16 ± 3
		II	38 ± 5	28 ± 2
		IV	74 ± 34	73 ± 3
N-7	Thermochemical test area large waste pond	I	37 ± 6	29 ± 4
		II	8 ± 2	44 ± 4
		V	352 ± 46	
N-8	Thermochemical test area large waste pond	I	15 ± 3	28 ± 4
		IV	158 ± 41	-
N-9	Ditch 26 at NW corner of NASA	I	172 ± 40	41 ± 4
		II	10 ± 2	34 ± 3
		V	184 ± 37	80 ± 4
N-10	Ditch 25 at large storm drain entrance	I	26 ± 5	24 ± 3
		IV	235 ± 33	74 ± 4
N-11	Ditch 25 upstream of siphon under HL&P canal	I	30 ± 4	59 ± 5
		II	39 ± 6	37 ± 3
		IV	116 ± 29	73 ± 4
N-12	Duck pond south of Building 8	I	59 ± 8	10 ± 3
		IV	190 ± 34	58 ± 3

* SAMPLE DATE LEGEND

I	9/18/64	V	5/5/65
II	1/20/65	VI	5/12/65
III	4/6/65	VII	5/14/65
IV	5/3/65	VIII	5/18/65

TABLE 5

GROSS BETA-GAMMA COUNT OF OFF-SITE SAMPLES

SAMPLE POINT	LOCATION	SAMPLE DATE*	GROSS BETA-GAMMA WATER pc Tl-204 Equiv/liter	GROSS BETA-GAMMA BENTHAL pc Tl-204 Equiv/gm wet wt.
1	Hwy 75 bridge @ Clear Creek	I	27 ± 4	41 ± 4
		V	280 ± 36	48 ± 2
3	Cow Bayou north of F.M. 528	I	180 ± 23	63 ± 6
		II	1730 ± 242	39 ± 4
		V	582 ± 58	87 ± 4
5	NASA sewage treatment plant outfall ditch above confluence with H. L. & P. canal	I	330 ± 50	21 ± 5
		II	20 ± 3	28 ± 3
		IV	154 ± 31	76 ± 3
6	HL&P outfall canal above confluence with NASA sewage treatment plant outfall ditch	I	97 ± 18	25 ± 4
		IV	916 ± 73	6 ± 2
7	Outlet of Mud Lake into Clear Lake at FM 528 bridge	I	112 ± 17	11 ± 3
		II	366 ± 51	32 ± 3
		IV	474 ± 52	55 ± 3
9	Horsepen Bayou above confluence with Clear Lake City sewage treatment plant outfall	I	46 ± 8	45 ± 5
		IV	178 ± 30	101 ± 5
10	Clear Creek at HL&P intake canal structure	I	159 ± 16	36 ± 5
		II	425 ± 55	30 ± 3
		IV	500 ± 50	196 ± 6
12	Humble Salt Water Canal and Drainage channel	I	530 ± 48	45 ± 5
		II	2030 ± 284	37 ± 3
		III	1906 ± 210	112 ± 2
		V	918 ± 92	234 ± 4
13	Clear Lake near outlet of HL&P canal	I	87 ± 11	18 ± 2
		IV	518 ± 41	69 ± 3
14	HL&P canal downstream of points 5 and 6 @ siphon under F.M. 528	I	132 ± 21	37 ± 5
		II	269 ± 40	28 ± 3
A	Drainage ditch from Clear Lake above confluence w/HSW Canal	III	101 ± 33	36 ± 1
		IV	252 ± 45	90 ± 5
B	Humble Salt Water Canal northernmost point east of Hwy 3	III	1697 ± 178	66 ± 2
		IV	6832 ± 4100	131 ± 4
C	Humble Salt Water Canal west of Hwy 3	IV	2738 ± 274	273 ± 5

* SAMPLE DATA LEGEND

I	9/18/64	V	5/5/65
II	1/20/65	VI	5/12/65
III	4/6/65	VII	5/14/65
IV	5/3/65	VIII	5/18/65

IV. MONITORING AT THERMOCHEMICAL TEST AREA

Of the various operations conducted or planned at MSC, the Thermochemical Test Area (TTA) possesses the greatest potential for the creation of air and water pollution problems because of the reactive and toxic nature of the materials used in that area. Much of this work is conducted with systems that utilize nitrogen tetroxide (N_2O_4) as oxidizer and Aerozine mixtures (hydrazine and unsymmetrical dimethyl hydrazine) as fuel. Because of these hazards, suitable precautions were incorporated into the design of facilities for this area and operating procedures were developed to provide adequate safeguards for both MSC personnel and for off-site areas.

As an additional precaution, monitoring was performed under this contract to be sure that no pollution problems were created. This monitoring consisted of sampling and analysis of both air and water around the TTA, to be sure that any losses of fuel and oxidizer were within acceptable limits. Monitoring was started in March, 1965 when fuels and oxidizers were brought into the TTA for the first time, and was continued intermittently thereafter. Coordination with TTA personnel was maintained so that some of the monitoring was performed during periods when firing tests or handling of fuel and oxidizer created the greatest potential for contamination.

A. Atmospheric Monitoring

Atmospheric monitoring was conducted with the mobile laboratory described previously. This made it possible to obtain data immediately at any location as desired. Figure 7 shows a map of the Thermochemical Test Area and surrounding areas indicating the sampling locations within a radius of 150, 300, and 600 feet of Building 353. These sampling areas were selected rather than the site boundary since the time required for atmospheric contaminants to be transported to the site boundary increased the probability of shifts in wind direction which would make it more difficult to select sampling locations to illustrate the maximum concentrations encountered. Some sampling was also conducted along the north boundary, but it is felt that the most reliable results were obtained by sampling closer to the source.

Tests were made for nitrogen dioxide, oxidant, hydrazine and UDMH. NO_2 was determined by the Saltzman method and oxidant by the potassium iodide method. Oxidant measurements were included because nitrogen dioxide is capable of reacting in the atmosphere with hydrocarbons or other organic compounds to form reaction products that can cause eye irritation and vegetation damage; this reaction in the presence of sunlight is responsible for the well-known smog problems in California and to a lesser extent in other parts of the country. Therefore, monitoring for such reactions was

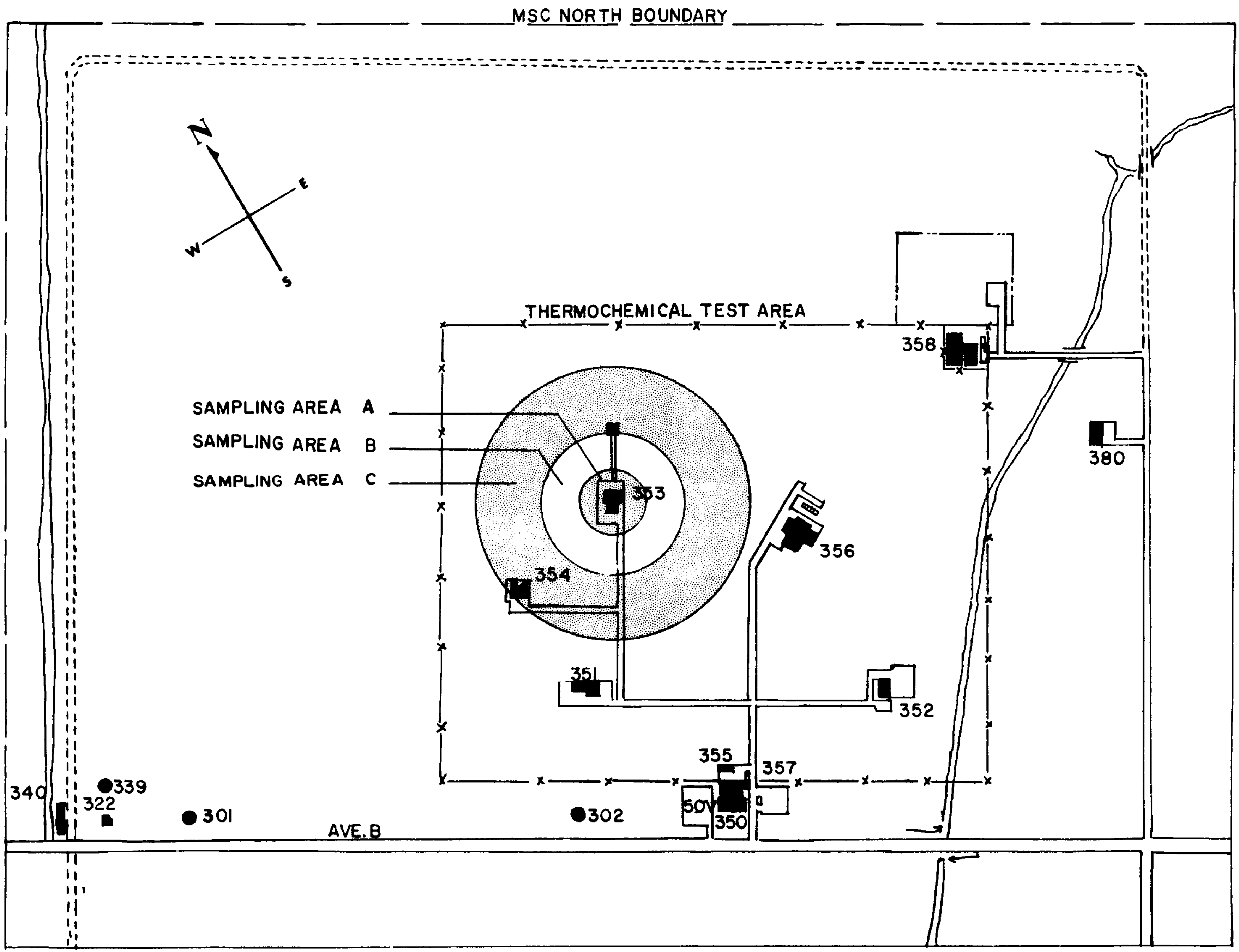

FIGURE 7 - THERMOCHEMICAL TEST AREA AIR SAMPLING AREAS

400 0 400 800
SCALE - FEET

important to determine whether or not NO_2 released in the Thermochemical Test Area might accelerate such reactions. Other sampling, however, has demonstrated that the hydrocarbon concentration in the atmosphere is normally quite low and thus such reactions would not be expected; however, oxidant measurements could be made simultaneously with the other measurements and provided an added factor of safety.

Table 6 is a compilation of all the atmospheric data obtained. The table also lists wind directions and sample areas so that the approximate sampling location can be determined. During these periods, successive determinations were run one after the other as rapidly as possible. All values shown are the maximum concentrations obtained during each monitoring period. In most cases, the value reported was an isolated run, and did not represent an average for the period.

Values shown for nitrogen dioxide were mostly in the low range, less than 0.01 part per million. Such values may not be related to any operation in the Thermochemical Test Area, and may come from the steam boiler plant or from automobile exhausts on-site and in the surrounding communities. NO_2 is formed by any high temperature combustion process and thus can be found in very low concentrations near any city or industrial operation. There is also a possibility of minor interference in the chemical analysis, so that values of .001 and .002 may not be significant. However, values in excess of 0.01 probably indicate vapor escaping from the Thermochemical Test Area. While these were rather infrequent, such values did occur on occasion and demonstrated the value of the buffer zone between the Thermochemical Test Area and the site boundary. The highest values obtained (0.8 and 1.0 ppm) are higher than would be desired at the site boundary. However, by the time these concentrations had reached the site boundary some 1600 feet away, normal atmospheric dispersion undoubtedly reduced these concentrations to levels which were not hazardous for a brief interval of time. During some periods however, operating personnel in the mobile laboratory reported that detectable odor and minor irritation were noticed at the sampling location. During such periods, the operators either left the area or used a gas mask.

Hydrazine and UDMH concentrations were sufficiently low in all runs to indicate that no hazard would exist at the site boundary. Again, a few isolated values were obtained in the sampling area which would be undesirable at the site boundary, but dispersion in the intervening distance should have eliminated any hazard.

TABLE 6 THERMOCHEMICAL TEST AREA AIR SAMPLING DATA - 1965

Date	Period of Day Monitored	Sample Area*	Wind Direction	Maximum Concentration - ppm NO_2	Hydrazine	UDMH	Oxidant	Remarks
3/11/65	1315-1400	Waste Pond	SE	.071	0	0		
3/30/65	1240	A	NNE	.003	0	0		
3/31/65	1120-1545	A	N-NE	.005	0	0		Loading propellant 1410-1445
4/1/65	1245-1437	A	E	.004	.004	0		Firing
4/15/65	1120-1355	A	W	.004	.005	0		
4/16/65	1002-1320	A	NE-SE	.004	0	0		Firing 1002
4/19/65	1410-1600	A	SE-NE	.003	0	0		Released oxidizer 1405
4/23/65	1200-1400	B	E	.001				Background
4/23/65	1200-1400	B	E		0	0	.028	Firing
4/26/65	1245-1415	B	E-SE	.003	0	0		Firing
4/27/65	1240-1545	A&B	N-NNW	.002	0	0		Firing
4/28/65	1027-1615	B & 1 mile S Bldg 353	N-NNE	.001	.007	0	.067	Firing
4/29/65	1030-1358	A	E-NE	.003	0	0	.031	Firing
4/30/65	1000-1300	A&B	NNW-E	.002	.002		.092	No firing after 1000
5/3/65	1145-1455	A	SE	.003	0	0		Loading fuel into 3 gal. container (odor of fuel)

* See Figure 7 for location of sampling areas. Sampling was always done downwind from the source in the sampling area indicated.

TABLE 6 THERMOCHEMICAL TEST AREA AIR SAMPLING DATA - 1965

Date	Period of Day Monitored	Sample Area*	Wind Direction	Maximum Concentration - ppm NO_2	Hydrazine	UDMH	Oxidant	Remarks
5/4/65	1310-1438	A	ESE	.009	.009	.276	.003	Loaded fuel in 2-500 mb flasks (strongest odor to date)
5/10/65	1215-1245	A	SE	.002	0	0		Loading fuel into cell
5/11/65	1100-1300	A&B	SSE	.124	0	0	.016	1100 loading oxidizer; 1300 firing
5/12/65	1400-1440	A	E	.005	0	0	.026	Working on equipment in cell
5/13/65	1130-1345	A	E-SE	.005	0	0	.028	
5/14/65	1235-1500	A & Waste Pond	SE-E	.005	0	0	.010	Firing
5/17/65	1330-1550	A	SE	.810	0	0		Loaded fuel 0600-0700; loaded oxidizer 1000-1100
5/18/65	1030-1215	A&B	SE	.003		0		Firing
5/19/65	1225-1430	A	E-ESE	.013	.005	0		Firing; 1430 released oxidizer
5/26/65	1110-1315	A	SSE	.003	0	0		No odor after firing
5/27/65	1400-1530	A & North Boundary Line	SSE	.003	0	0	.004	Slight or no odor after firing
5/28/65	0915	A	SE	.106	.005	.049		Bleeding fuel & oxidizer lines
6/2/65	0930-1310	A	SSE	.010	0	0	.030	Misfire; bleed N_2O_4 line
6/3/65	1355-1529	A	SE	.003	0	0		Test firing

* See Figure 7 for location of sampling areas. Sampling was always done downwind from the source in the sampling area indicated.

TABLE 6 THERMOCHEMICAL TEST AREA AIR SAMPLING DATA - 1965

Date	Period of Day Monitored	Sample Area*	Wind Direction	Maximum Concentration - ppm NO_2	Hydrazine	UDMH	Oxidant	Remarks
6/4/65	0950-1023	A	SSE	.004	0	0		Firing
6/7/65	1150	A	SSE	.003	0	0		Loaded cell
6/9/65	0920-1320	A & North Boundary Line	SE	.005	0	0	.012	Drawing samples of N_2O_4 and fuel into container in cells 0920. Having difficulty in cell
6/11/65	0945-1215	B	N	.074	0	0	.096	
6/14/65	1510-1540	A	E	.003	0	0		Cold flow fuel only (ran fuel through system without firing)
6/16/65	1235-1347	A	E	.002	0	0		Test fire
6/17/65	1500-1500	A	SE	.002				Loaded oxidizer in AM
6/18/65	0927-1230	A	NE	.392	.133	.582		Grab sample of N_2O_4 and fuel. Loading fuel in cell
6/21/65	1530-1600	A	SSE	1.060	0	0		Long fire (30 sec.)
7/6/65	1225-1440	A	E-S-SE	.016	0	0		
7/7/65	1000-1416	C	SW-SSE	.009	0	0		Test fired in vacuum chamber
7/8/65	1140-1545	C	S	.005	0	0	.027	Test fired in vacuum chamber No odor.
7/9/65	0920-1020	C	S	.156	0	0	.041	Dumping N_2O_4 for 4 min.

* See Figure 7 for location of sampling areas. Sampling was always done downwind from the source in the sampling area indicated.

TABLE 6 THERMOCHEMICAL TEST AREA AIR SAMPLING DATA - 1965

Date	Period of Day Monitored	Sample Area*	Wind Direction	Maximum Concentration - ppm NO_2	Hydrazine	UDMH	Oxidant	Remarks
7/20/65	0930-1545	A	S	.012	.003	0	.017	Firing
7/21/65	1255-1315	A	SE	.002	0	0		Test firing
7/22/65	1255-1545	A	SE	.004	0	0	.081	Test firing
7/23/65	1125-1200	A	NE-WSW	.004	0	0		Load fuel into cell
7/27/65	1130-	Waste Pond	WSW	.002	0	0		
7/28/65	0950-1034	B	W	.002	0	0		Firing
7/30/65	0955-1251	A	N-NE	.004	0	.007		Firing
8/2/65	1545	North Boundary Line	SE	.002	0	0		Bleeding few drops fuel and oxidizer periodically
8/10/65	1300-1400	C & Moon Base	NE	.005	0	0	.039	
8/24/65	1300	C	Calm	0	0	0		
9/8/65	1245-1650	Bldg 356	ENE	.010				Transferred 10 gal N_2O_4 from test system to tank. Bled N_2O_4 line.
9/9/65	0930							No activity. Waste pond system being overhauled.
9/27/65	1048-1400	A	N-NNE	.019	.005	.010		Finished loading oxidizer in cell Loading fuel in cell. Taking samples of N_2O_4 and fuel.

* See Figure 7 for location of sampling areas. Sampling was always done downwind from the source in the sampling area indicated.

TABLE 6 THERMOCHEMICAL TEST AREA AIR SAMPLING DATA - 1965

Date	Period of Day Monitored	Sample Area*	Wind Direction	Maximum Concentration - ppm NO_2	Hydrazine	UDMH	Oxidant	Remarks
9/28/65	1105-1442	A	NE-NNE	.008	.005	0	.035	Background. Venting small amounts of N_2O_4 periodically in cell due to S tank valve.
9/30/65	0945-1000	B	W	.005	0	0		Bleeding fuel and oxidizer lines in cell.
10/8/65	1330-1548	A&B	SW	.079	0	0		Loading N_2O_4 and fuel into cell. Collected samples of N_2O_4 and fuel in metal cylinders for NASA lab.
10/12/65	1520-1615	A	N	.010	0	0	.039	
10/14/65	1535-1630	A	ESE	.003	0	0	.007	Test fired
10/19/65	1440-1550	A	NW	.005	0	0		Test fired. Sampled 55 gal drum MMH.
10/20/65	0920-1520	A	NNW-NNE-N	.004	.011	.010	.044	Bleeding fuel lines and tank in cell (approx .5 gal) First firing with MMH.
10/22/65	1355-1510	B	WNW-NW		.003		.051	Firing
11/19/65	0940-1000	A	S	.227			.003	4 min. venting N_2O_4.
12/1/65	1515-1630	C	E	.003	0	0	—	Firings in subsystem chamber

*See Figure 7 for location of sampling areas. Sampling was always done downwind from the source in the sampling area indicated.

TABLE 6 THERMOCHEMICAL TEST AREA AIR SAMPLING DATA - 1966

Date	Period of Day Monitored	Sample Area*	Wind Direction	Maximum Concentration - ppm NO_2	Hydrazine	UDMH	Oxidant	Remarks
1/7/66	1200	A	W	.004	—	—	.016	
1/7/66	1315-1340	C	W-E	.003	—	—	.037	Loading N_2O_4 at N end of Bldg. 353
1/28/66	0930-1055		E	.003	0	0	0	Flushing out N_2O_4 lines with Freon. Could not get downwind with Mobilab because of muddy conditions
2/8/66	0900-1410	A	SE-SW	.004	—	0	.016	No loading or firing
2/19/66	0950-1110	C	NNE	.004	0	0	.032	Test facility to test fire 9-10 times (started 0950) in vaccum chamber downwind of steam exhaust from vac. chamber. Firings approx 5 min. apart for 1 hour.
2/24/66	1145-1415	B	N	.002	—	—	.048	Faint acrylate odor
3/22/66	1230		S	.001	0	0	.021	Test firing in small vacuum chamber at Bldg 353
3/30/66	1410		W	.002	0	0	—	Reddish orange vapors noted coming from steam ejectors at 353. Lasted approx 4-5 secs. No odors. Noted downwind of 353. Continued to watch for next 30 min. No more vapors noted.

*See Figure 7 for location of sampling areas. Sampling was always done downwind from the source in the sampling area indicated.

TABLE 6 THERMOCHEMICAL TEST AREA AIR SAMPLING DATA - 1966

Date	Period of Day Monitored	Sample Area*	Wind Direction	Maximum Concentration - ppm NO_2	Hydrazine	UDMH	Oxidant	Remarks
4/4/66	1235-1330	A	N	.158	0	0	.046	Large amount of N_2O_4 vapors Very strong odor
4/12/66	0900		SSW	.003	0	0	.002	No loading or firing.
4/15/66	1100-1550	B	NNE	.003	0	0	.014	Working on new engine set up.
5/12/66	1230		SSE	.002	0	0	.019	
6/15/66	1015-1100		N-S	—	—	—	—	100 ft. downwind open drum of NH_3OH. Moderate NH_3 odor. Could not get exactly downwind of NH_3.
8/10/66	1330			.005	—	—	—	Strong irritating and choking odor from cement dust during chipping of cement with air hammer.

*See Figure 7 for location of sampling areas. Sampling was always done downwind from the source in the sampling area indicated.

Most oxidant values were in the range normally associated with atmospheric ozone formed by natural processes. On rare occasions, values of 0.08 to 0.09 ppm were obtained, indicating the possibility of a photochemical reaction not due to natural causes. On most of these occasions, however, the wind was from the north or northwest, and thus the contaminants causing the elevated oxidant values probably originated in the industrial area along the Houston Ship Channel. There is no evidence that operations at the Thermochemical Test Area were responsible for any significant increase in oxidant-producing photochemical reactions in the area.

In summary, all of the data obtained indicated that the precautionary measures observed at the Thermochemical Test Area were adequate to prevent off-site atmospheric pollution. Concentrations in the immediate area were sometimes higher than would be desired off-site, but the intervening distances provided an adequate buffer zone for dispersion and dilution in the atmosphere.

B. Water Monitoring

Water contamination would be undesirable in either surface or ground water. Monitoring was conducted in test wells provided on all four sides of the TTA boundary near the area boundaries, and in drainage ditches which carried runoff and other surface water from the area. Tests were also made on the holding ponds provided for neutralization and disposal of TTA process water.

Tables 7 and 8 present the results obtained in this monitoring. No evidence was found of ground water contamination from TTA. The only evidence found of surface water contamination was during the authorized disposal of fuel at the waste pond area in July, 1965. This disposal was monitored to insure that contaminant levels were safe for the environment.

	East Test Well	*South Test Well	West Test Well	North Test Well
pH - Units	8.1	8.3	8.0	8.0
Total Residue	825	1015	694	610
Filtrable Residue (Dissolved Solids)	500	608	399	400
Non-Filtrable Residue (Suspended Solids)	324	407	296	212
Ca	37	40	35	33
Mg	27	41	25	38
Na & K (by diff.)	125	185	102	63
SO_4	5	13	3	4
Cl	74	144	57	44
F	0.8	0.9	0.5	0.5
NO_3	1.3	2.1	1.6	2.0
Alkalinity				
P - mg/l as $CaCO_3$	0	0	0	0
M - mg/l as $CaCO_3$	368	428	300	314
Hardness - mg/l as $CaCO_3$	210	263	191	241
Conductivity - micromho	780	941	630	590
COD	7	8	5	13
UDMH	0	0	0	0
Hydrazine	0	0	0	0

*Note: Data shown are averages of three analyses made on separate water samples from the South Test Well. Data shown for the other wells are averages of 6 to 9 analyses made on samples taken at intervals from October 1964 through June 1966. All analyses are shown as mg/l unless noted otherwise.

TABLE 7 THERMOCHEMICAL SHALLOW TEST WELL - AVERAGE WATER ANALYSES

Date	Mixing Reservoir UDMH	Mixing Reservoir Hydrazine	Holding Reservoir UDMH	Holding Reservoir Hydrazine	Remarks
3/30/65			0	0	
3/31/65	0	0	0	0	
4/1/65			0	0	
4/15/65	0	0	0	0	
4/16/65	0	0	0	0	
4/26/65	0	0	0	0	
4/27/65	0	0	0	0	
4/28/65			0	0	
5/4/65	0	0	0	0	
5/10/65			0	0	
5/14/65	0	0	0	0	
5/28/65	0	0	0	0	
6/2/65	0	0	0	0	
6/7/65	0	0	0	0	
6/18/65	< .001 mg/l	0	< .001 mg/l	0	
7/8/65	0	0	< .01 mg/l	0	
7/12/65	0	0	10.0 mg/l	13.0 mg/l	Authorized fuel dump
7/22/65	84.0 mg/l	85.0 mg/l	0	.03 mg/l	
7/23/65	33.0 mg/l	34.5 mg/l	0	.03 mg/l	
7/26/65	14.0 mg/l	15.7 mg/l	0	0	Algae growth in mixing reservoir 50 lbs. $CaSO_4$ added.
7/27/65*	14.5 mg/l	14.5 mg/l	0	.03 mg/l	Started pumping to sewer
7/28/65	4.2 mg/l	5.0 mg/l	0	0	
7/30/65	—	0.40 mg/l	—	.03 mg/l	
9/8/65	0	0	0	0	
10/12/65	0	0	0	0	
12/8/65	0	0	0	0	
3/15/65	—	—	0	0	

* Note: The following analyses were made of sewer outfall at entrance to HL&P canal and after mixing with canal water.

	UDMH	Hydrazine
Sewer outfall	3.0 mg/l	3.4 mg/l
HL&P canal	0	0

TABLE 8 TTA WASTE PONDS MONITORING DATA - MARCH 1965 TO MARCH 1966

V. INVESTIGATION OF ON-SITE PROBLEMS

As specific problems or potential problems were identified at MSC, investigations were made as appropriate to obtain information to aid in planning corrective or preventative action. Letter reports were prepared covering these various investigations, and therefore details will not be repeated here. The following listing shows the reports that were submitted covering investigations of on-site problems not otherwise covered in this report.

LISTING OF NASA REPORTS Contract NAS 9-3419

October 23, 1964	Investigation of Possible Air Contamination Problems
February 18, 1965	Monitoring at Thermochemical Test Area
March 4, 1965	Laboratory Waste Treatment Study
June 2, 1965	Investigation of Pre-clean Room
June 18, 1965	Investigation of Mercury Vapor, Building 15
August 5, 1965	Radiological Background for Low Level Counting Laboratory Location
September 28, 1965	Investigation of Mercury Vapor
November 15, 1965	Investigation of Sound Levels
December 3, 1965	Investigation of Sound Levels
December 27, 1965	New Federal Standards for Water Pollution Control
January 13, 1966	Modifications for Clean Room Area, Second Floor, Building 15
January 21, 1966	Investigation of Reported Noise Problem, Building 417
January 26, 1966	Pre-clean Room, Building 356
January 26, 1966	Photographic Technology Laboratory Waste
January 27, 1966	Bacteriological Test on Tap Water, Building 354
February 7, 1966	Mercury Vapor Measurements, Building 15
February 9, 1966	Atmospheric Monitoring, Thermochemical Test Area
March 1, 1966	Photographic Technology Laboratory Waste
March 11, 1966	Requirement for Meteorological Data at MSC
March 17, 1966	Noise Level Complaint, Building 30, Room 3044

LISTING OF NASA REPORTS (continued)

March 18, 1966	Rubber Compounding, Building 13, High Bay Area Mezzanine, Room 266
March 25, 1966	Micrometeorite Gun, Building 1162, Ellington AFB
March 31, 1966	Noise Level Study, Building 353, Steam Ejector
April 4, 1966	Lighting Survey, Building 420, Bin Storage
April 19, 1966	Spray Paint Odors, Building 4, Room 278
April 19, 1966	TTA Waste Ponds, Pond Leakage and Liners
April 28, 1966	Mercury Vapor, Building 15
May 6, 1966	Mercury Vapor, Building 15
May 6, 1966	Instruments, Reagents, Glassware and Materials Stock Lists for Environmental Control Laboratory Building 365, Ellington AFB
May 10, 1966	Illumination Survey, Building 10
May 10, 1966	Heavy Machine Shop, Room 125
May 10, 1966	Instrument Machine Shop, Room 120
May 12, 1966	Report on Investigation of Facility Central Compressed Air System for Breathing Purposes
May 19, 1966	Ditch 25 - May 12, 1966, Report of Green Color and Dead Fish
June 28, 1966	Mercury Vapor Contamination, Building 29
June 28, 1966	Federal Regulations regarding Air Pollution Control
July 6, 1966	Investigation of Fabric Shop, Building 7
July 13, 1966	Water Sample from Spacecraft 008
July 15, 1966	Smoke and Odor Problem, Building 135, Ellington Field

LISTING OF NASA REPORTS (continued)

July 15, 1966	Report on Fume Problem, Welding Shop, Building 10
July 15, 1966	Cadmium Fumes, Micrometeorite Simulation Lab. Lab.
August 5, 1966	Water Samples from Spacecraft 008
August 11, 1966	Letter enclosing two copies of standard methods: Determination of UDMH in Water Determination of UDMH in Air Determination of Hydrazine in Water Determination of Hydrazine in Air Determination of Monomethylhydrazine (MMH) in Water Determination of Monomethylhydrazine (MMH) in Air
August 12, 1966	Industrial Hygiene Problems, Building 13
August 29, 1966	Survey of MSC Sewage Treatment Plant
September 29, 1966	Sign Shop, Building 1163, Ellington Field
September 29, 1966	Executive Order 11282 "Control of Air Pollution Originating from Federal Installations"
October 7, 1966	Review of Plans for Photogrammetric Lab., Building 8
October 7, 1966	Inspection of Ovens in Potting Lab., Building 10
October 11, 1966	Analysis of Water Sample from Spacecraft 008